Getting A Handle On Norovirus Foodborne Transmission Mechanisms: A study for the Food Standards Agency

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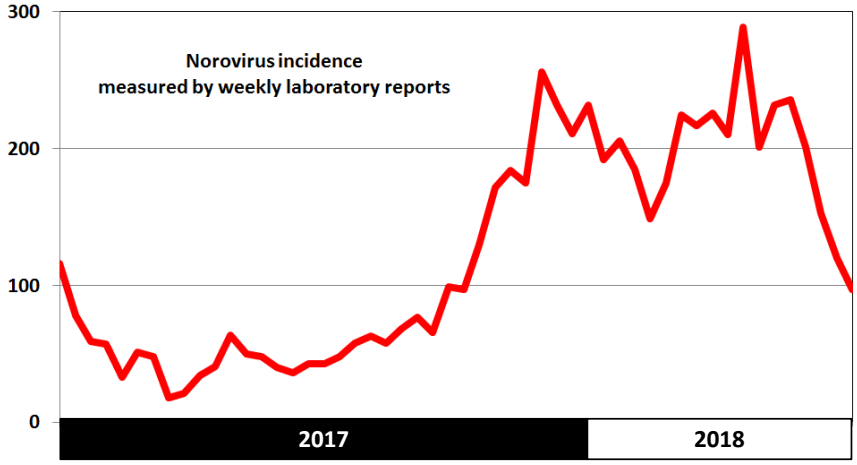
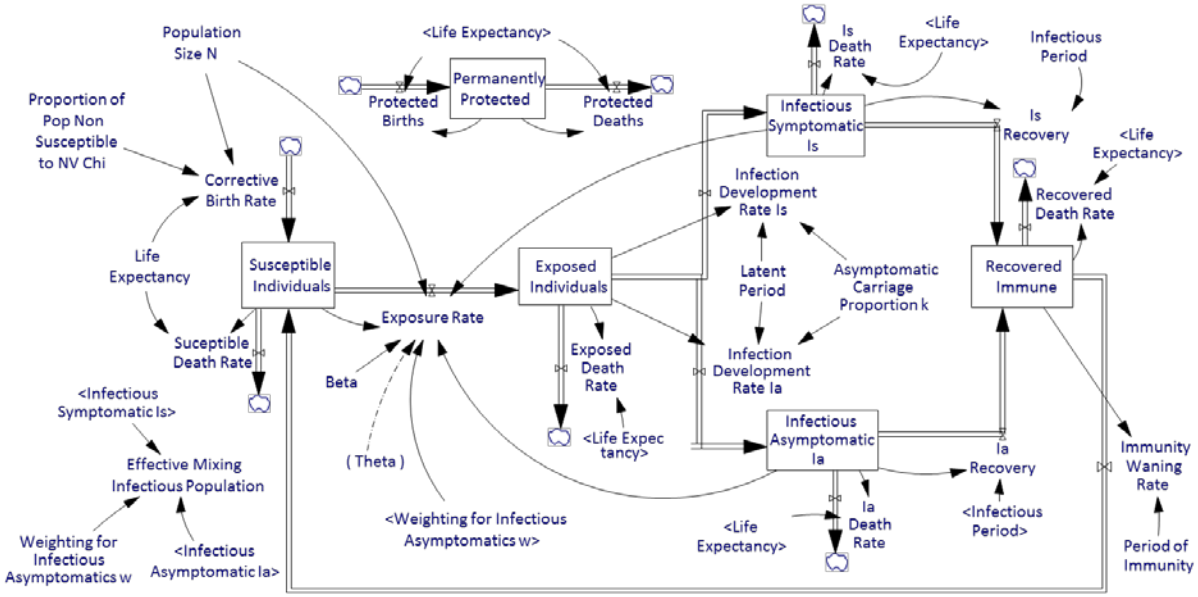
Extended Abstract:
The paper concerns modelling activities undertaken in a research study for the UK's Food Standards Agency (FSA).
Noroviruses are segments of RNA within a protein coat, simple sub-microscopic entities about ~30 nanometres across. In humans, Norovirus is transmitted via person-to-person contact (P2P) and via foodborne (FB) transmission. Norovirus is an enteric pathogen: in the human intestinal tract it causes short –lived but very unpleasant illness. It is referred to as the 'winter vomiting bug' because of the strong seasonality of incidence (see data from Public Health England):



The FSA commissioned a study to improve understanding of FB mechanisms, and to give recommendations on where it might focus its efforts. The work had two main elements.
First, an existing P2P model with a single, exogenous parameter for FB transmission was transformed into a System Dynamics model of FB processes. The modelling involved individual interviews and a group-modelling session (the FSA arranged access to key experts). Transmission routes modelled concerned: bi-valve shellfish; sludge; fruits and vegetables; other foodstuffs. The result was the first, fully endogenised formulation of the main foodborne transmission mechanism of Norovirus.
As FSA had predicted, the full parameterisation of this model was not possible given the current state of research. However, the modelling went considerably beyond project expectations in terms of capturing knowledge about the transmission mechanisms. This work on the detailed modelling of FB transmissions demonstrated the effectiveness of a combination of individual sessions with domain experts and a facilitated group modelling session. The resulting model represented the underlying causal mechanisms – the first ever model of these mechanisms - demonstrated that modelling the FB mechanisms is possible and was a significant achievement in the eyes of the FSA. Moreover, the model allowed the categorisation of parameters in a manner which was useful in agenda-setting for future research and in identifying policy levers.

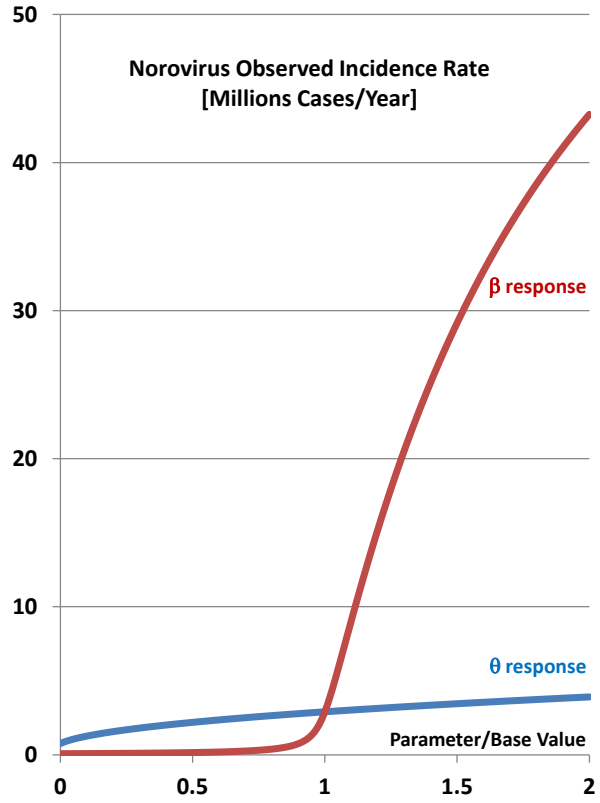


Creative thinking extended the work in a significant way and resulted in the second main element.

Mathematical analysis made it possible to return to the P2P model (shown above) and, for the first time, calibrate it using empirical data. For the first time this gave the FSA a quantification the scope of P2P and FB effects.

Sensitivity analysis then led to two key findings.

First, that the structure of the system meant that quite small changes in human behaviour could, in fact, explain the large Norovirus seasonal variations. Second, that the relative importance of transmission vectors indicated a potential for quite different marginal improvements in Norovirus incidence. This is illustrated by the chart (right) showing sensitivity of P2P transmission ('β response') and FB transmission ('θ response') effects



An anonymous expert review of the final study report commented that, "The modelling work … identified important sensitivities, non-linear effects and parameter uncertainties". Strikingly, another review comment observed that, "intervention in person-to-person virus transmission and associated public health policies, whilst falling outside the FSA's remit, could be as important as foodborne vectors." This is a challenging message for the FSA, an organisation whose remit is food. Nevertheless, it was accepted because it was grounded in rigorous and effective System Dynamics modelling.

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